

[about DNA / NOT about evolutionary history, about mechanism of evolutionary change]

Setting the stage - neoDarwinism

Gene concept – 1926 (Morgan) – transmission genetics, really a semantic convention, talking as though “this allele of this gene causes this trait.” -- Gave a way of creating a more comprehensive the theory of evolution. AT THIS POINT the theory of evolution by natural selection finally started to be accepted.

- population – pool of genes, differ alleles mixing and mutating randomly, mathematical statistics
- speciation depending on isolation of smaller populations
- atomistic, gene = trait, independent – generalized model of mechanism of adaptive change, but *not* mechanism of generation of forms, or mechanism of creation of genetic change.
- punctuated equilibrium PICTURE [seen by paleontologists, in strata ~50,000]
- Bacterial experimental – fitness increased in jumps then slower fine tuning

So... CHANGES Random genetic change by random mutations.

BUT evidence shows this is not the case...

Shapiro

New view of life forms as self modifying beings – from mechanistic to informatic view.

Cells as sensing, cognitive, Boolean logic, with all classes of molecules participating. Proteins as microcomputers.

Mutations are not random

– eg UV radiation in bacteria – repair of DNA damage is perfect. Mutations are created “on purpose”. SOS response:

System 1. Repair error-free

System 2. a mutagenic repair process that synthesizes specialized error-prone DNA polymerases, which can replicate DNA that contains unrepaired damage. Without these, mutations do not occur. And – different types of point mutations are caused by different types of mutagenic polymerases.

System 3. Proteins that promote recombination of homologous genes (alleles/chromosomes), alter metabolism, inhibit DNA replication

Formatting

Genome as a Read-Write storage system, subject to non-random change by dedicated cell functions. Some restructuring for normal function, but also for evolutionary change.

- Epigenetics as “formatting” the genome -- indexing it, guided by ncRNAs – “brain” as platform for genome restructuring.
- Junk DNA - Repetitive sequences, inactivated RETROviruses and jumping genes → affect gene expression. These are the main differences between animal groups.

Mechanisms of NGE

- Mutagenic DNA polymerases
- DNA import/export systems – horizontal DNA transfer between species is widespread
- Types of recombination
- Transposons and retroviruses → genetic fusions, insertions, deletions, inversions – some insert into specific DNA sequences, some take functional genes with them, making any genetic element mobile and recombinable. Often restricted to germline cells, with greatest evolutionary impact. In *Drosophila*, retroviruses are agents of mutations causing changes in morphology.
- Whole genome duplications. hybridization
- Symbiogenesis – mito and cloro – caterpillar and butterfly as hybrid of two genomes
- Use and reuse – Hox PICTURE [& DEVEL PICTURES IF TIME]

Result

Natural selection is not just for adaptation but *adaptability*: genome structure gives cooperativity, increases odds of functionality (shared controls and interaction sites)

H1 – Targeting NGE to multiple genome regions that code for functionally related molecules and producing similar or complementary changes in these different regions simultaneously will increase the chance of a workable invention.

H2 – Mechanisms for this exist:

(a) **P element homing in *Drosophila*** – get preferential insertion in regions that have common regulation. [These are transposons that go to germ cells in *Drosophila*; cloning DNA into P elements is now the standard for creating transgenic flies. Surprised to find that the cloned DNA somehow directed the transposon where to insert itself. They get inserted in precisely those regions where proteins that recognize that cloned DNA are active.]

(b) co-localization of functionally related loci. Advantage to grouping them so that a coordinated change can happen.

H3 – There's a link between ecological disruptions and genomic changes – don't yet know.

H4 TO TEST – To what degree can cell sensing, information processing, and genome targeting (of NGE) guide and accelerate the production of useful novelties in evolution? [A priori, functionally relevant guidance or “direction?”]

New conceptual basis for evolution

Stress induces NGE of particular types. Emphasis on molecular level signaling/stresses coupled to novelty creation and re-engineering at high rate, otherwise tightly conserved – matches punctuated equilibrium.

Engineering by reorganizing established functions to create novelty : – hierarchical – level of exon (domain swapping), enhancer (executes algorithm), whole locus, chromosome segment. Thus: modular mixing is more adaptive than gradual accumulation of point mutations.

Engineering by generating novelty – exon/intron situation: rapid generation of novelty; junk DNA as expanded resources & raw materials; virosphere least constrained – source of much novelty. (Virolution)

21st Century Theory of Evolution:

- Cells as cognitive/sentient
- Cells built to evolve
- Evolutionary novelty arises from cellular self-modification
- NGE responds to stimuli that put the organism's survival, growth, or proliferation in peril. Usually ecological disruption.

READ END QUOTE – IF TIME [OPTIONAL]

READ KEVIN KELLY - IF TIME [OPTIONAL]